ELECTRIC MOTOR ACTUATED STOP AND SELF-CLOSING CHECK VALVE

CROSS REFERENCE TO RELATED APPLICATION

This application is a Continuation-in-Part of Application No. 09/507,273, filed February 18, 2000, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to electric motor actuated valves incorporating a check valve feature for controlling the flow of pumped liquids in applications such as are associated with municipal water supply or sewage treatment facilities and industry.

Description of Related Art

Valves for controlling liquid flow and preventing its back-flow are known in the art and are commonly referred to as stop/check valves. Such valves can be actuated to control liquid flow by manual, hydraulic and other means.

U.S. Patent No. 4,667,696 describes a stop/check valve which utilizes a ball which closes upon a valve seat to prevent liquid flow in a back-flow direction. Flow in a desired direction is regulated by a hand-cranked closing device acting on the ball.

U.K. Patent specification 141,148 describes a

stop/check valve for fluid having a pressure plate extending from a clack into a path of return flow of the fluid so as to urge the clack to a closed position. In an embodiment having control of forward-flow, a hand-actuated spindle is used to position the clack.

U.S. Patent No. 4,945,941 describes a stop/check valve having a feature facilitating movement of a valve disc to a closed position with back-flow of liquid by use of a ridge on the valve seat and a deflector ring on the valve disc to deflect the flow of the fluid. Control of the liquid for forward-flow is carried out with a hand-actuated valve stem.

SUMMARY OF THE INVENTION

The present invention is an electric motor actuated stop and self-closing check valve for controlling forward-flow and back-flow of liquid in a liquid conveying line and reducing liquid surge pressure transients and slamming of valve components. The valve has:

A) a valve body having an inlet port and an outlet port, relative to forward flow of a liquid,

B) a valve seat disposed within the valve body intermediate the ports,

C) a valve disc disposed within the valve body having an elongated disc stem which extends through the valve body, the valve disc and disc stem being moveable along the

longitudinal axis of the disc stem to either:

i) a closed position whereat the valve disc sealingly engages the valve seat to prevent forward-flow and back-flow of the liquid, or

ii) an open position whereat the valve disc is spaced from the valve seat,

D) a compression spring external to the valve body for providing a selected bias to the valve disc and disc stem toward the closed position;

E) an electric motor operationally attached to the valve, and

F) an actuator rod moveable by action of the electric motor so that the actuator rod is disposed at either:

i) an extended position of the actuator rod whereat the actuator rod contacts the disc stem and restrains the valve disc at the closed position preventing forward-flow and back-flow of the liquid, or

ii) a retracted position of the actuator rod whereat the actuator rod is retracted any amount from the extended position to be at a selectable retracted position, and, at all selectable retracted positions of the actuator rod the valve disc is moveable along the longitudinal axis of the disc stem, without further action by the electric motor, such that:

a) the valve disc moves to the open position solely through action of forward flowing liquid on the

valve disc and forward-flow of the liquid occurs, and

b) the valve disc moves to the closed position through action of the compression spring and momentary back-flowing liquid on the valve disc, and liquid back-flow is prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical cross-section of a wye valve of the invention with an actuator rod in an extended position and a valve disc in a closed position;

FIG. 2 is a vertical cross-section of the wye valve of FIG. 1 with the actuator rod in a fully retracted position, the valve disc in an open position and liquid flow in a direction from an inlet port to an outlet port;

FIG. 3 is a vertical cross-section of the wye valve of Fig. 1 with the actuator rod in a partially retracted position for regulating forward liquid flow, the valve disc in a partially open position, and liquid flow in a direction from an inlet port to an outlet port;

FIG. 4 is a vertical cross-section of the wye valve of FIG. 1 with the actuator rod in a retracted position and the valve disc in a closed back-flow preventing position;

FIG. 5 is a vertical cross-section of a wye valve embodiment of the invention having a closing speed regulator, an actuator rod in an extended position and a valve disc in a closed position;

FIG. 6 is a vertical cross-section of the wye valve of FIG. 5 with the actuator rod in a retracted position, the valve disc in an open position, and forward liquid flow in a direction from an inlet port to an outlet port;

FIG. 7 is a vertical cross-section of the wye valve of

FIG. 5 with the actuator rod in a retracted position and the valve disc in a closed back-flow preventing position;

FIG. 8 is a schematic diagram of a valve closing speed regulator of the invention;

FIG. 9 is a vertical cross-section of an elbow valve embodiment of the invention with the actuator rod in a retracted position and the valve disc in an open position for forward liquid flow in a direction from an inlet port to an outlet port; and

FIG. 10 is a schematic diagram for describing a method of operating a pumping system with use of a wye valve of the invention;

DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1-4 show an embodiment of the invention having a wye valve body which provides control of liquid flow when installed in-line with liquid conveying piping having a linear configuration. Wye valve **10** having valve body **12** is preferably installed in-line with use of flanges **14** and **16** which bolt together with matching flanges of the piping. Liquid flow is normally in the direction of arrows **18** and is referred to in this disclosure as forward-flow. In a typical application such flow would result from action of a pump up-stream of the valve. With forward-flow in the direction indicated by arrows **18** a port at **20** is referred to as an inlet port and the remaining port at **22** is referred to as an outlet port. Intermediate such ports and

substantially perpendicular to the flow of liquid is a valve seat **24**. In a preferred embodiment the seat is annular in shape, is replaceable, and is fabricated of a metallic material such as bronze or stainless steel. The seat can be either threaded and held in place by complimentary threads or pinned in valve body **12**, which is preferably of a metallic material such as cast iron or ductile iron. Liquid flow is controlled by interaction of valve seat **24** and a valve disc **26** having an integral disc stem **28**. In FIG. 1 valve disc **26**, is disposed in a closed position whereat it is in contact with valve seat **24** so as to block the flow of liquid through the valve body. Valve disc **26** in the preferred embodiment is of cast iron or steel and can be fitted with a valve disc seat, **30**, of a resilient material such as rubber or UHMWPE (ultra high molecular weight polyethylene) to provide a more positive seal between the valve seat and the valve disc. Such valve disc seat **30** is preferably retained by a bronze or stainless steel follower ring **32** attached to the valve disc with use of stainless steel screws **34**. Disc stem **28** is of stainless steel material. Clean-out/inspection ports **35** are provided in valve body **12** to view or gain access to the valve interior.

Disc stem **28** extends through a valve body cover **36** which in the preferred embodiment is provided with a bronze bushing **38** to enable substantially free movement of valve disc **26** and disc stem **28** along longitudinal axis **40** of the disc stem.

FIG. 2 depicts valve disc **26** and stem **28** at a position

referred to as a fully open position whereat liquid flow from inlet port **20** to outlet port **22** is enabled at full flow. Such flow position is contrasted with the valve disc position depicted in FIG. 1 which is referred to as the closed position and a partially open position described below and depicted in FIG. 3.

The valve of the invention is used in-line to 1) stop flow in the forward direction, 2) control flow in the forward direction (from full flow to a restricted flow) and 3) prevent back-flow (flow in a direction opposite to forward-flow). In the preferred embodiment, valve body **12** and valve seat **24** are dimensioned such that the net flow area is no less than the cross-sectional area of the piping to the inlet and outlet ports so as to minimize flow restriction by the valve. That is, the liquid does not encounter a cross-section, perpendicular to the direction of flow, which is of less area than the cross-sectional area of the adjacent piping. Configuration of the valve body, valve seat and valve disc is such that dead-end or non-flow cavities do not exist within the valve body and the valve is therefore said to be "self-cleaning".

Fig. 3 depicts valve disc **26** and stem **28** at a position referred to as a partially open position whereat liquid flow from inlet port 20 to outlet port 22 is restricted in relation to full flow referred to above in the description of Fig. 2. Although the valve disc **26** is shown at a selected position which is approximately one half open, in operation of the valve the valve

disc **26** can be set at any selected position between closed (Fig. 1) and fully opened (Fig. 2) by positioning an actuator rod (42) as is discussed below.

Operatively attached to valve body **12** is electric motor actuator **41** having actuator rod **42** positioned to act on valve stem **28**. Actuator rod **42** is preferably attached to a threaded shaft **43** which rotates through action of the electric motor to move it linearly along axis **40**. In event of loss of power or inoperability of the motor the threaded shaft can be actuated manually with a hand-crank **46**. Actuator rod **42** is prevented from rotating with the threaded shaft by an extension from the side of the actuator rod which extends into a slot in anti-rotation sleeve **47**. Gears linking electric motor **44** and hand-crank **46** to the threaded shaft are within housing **48**. A closed position of the valve as depicted in FIG. 1 is attained by action of actuator rod **42** against disc stem **28** to move the stem and valve disc **26** along longitudinal axis **40** to provide engagement of valve seat **24** with valve disc **26**. Contact of actuator rod **42** with disc stem **28** when in such closed position prevents an upward movement of disc stem **28** and valve disc **26** away from valve seat **24** which would result from pressure exerted on face **50** of valve disc **26** by liquid attempting to flow in the direction indicated by arrows **18**. Such actuator rod **42** position against disc stem **28** also prevents back-flow of liquid in a direction opposite to that indicated by arrows **18**.

FIG. 2 shows the position of valve **10** components when full flow of liquid in the forward direction is desired. Actuator rod **42** is at a fully retracted position by action of threaded shaft **43** rotated by electric motor **44**. Once the actuator rod is retracted valve disc **26** and disc stem **28** move in an upward direction along longitudinal axis **40** to position valve disc **26** to be spaced from valve seat **24** by sole action of the liquid flowing in the direction of arrows **18** and exerting pressure on face **50** of valve disc **26**. Actuator rod **42** is not connected to disc stem **28** and such lack of connection is an important feature of the invention and is relied on for prevention of back-flow of liquid which is described below. Liquid flow can be regulated to selected rates by positioning valve disc **26** between extreme positions. One example of such positioning is shown in FIG. 3. Operation of the valve to prevent back-flow of liquid as described above takes place at any and all partially open positions. The actuator rod **42** is retractable any amount from the extended position to be at a selectable retracted position, and at all of the selectable retracted positions the valve operates as discussed above.

As mentioned above, the electric motor actuated stop and self-closing check valve of the invention can be used in municipal water supply systems or sewage treatment systems as a pump control and stop check valve although it is not limited to such usage. In normal operation liquid flow is in the direction

indicated by arrows **18** with such flow provided by action of at least one pump upstream of the valve. In event of pump shutdown, either intended or by a power failure for example, back-flow of the liquid can occur when a valve to check such flow is not provided. Such back-flow is usually undesirable and is prevented by the valve of the invention without any action by the electric motor or an operator. Such feature is of importance when back-flow is caused by a power failure and power is not available to the electric motor.

In FIG. 4 the direction of such back-flow is indicated by arrow **52** and is in a direction from outlet port **22** toward inlet port **20**. In event of a pump shutdown, liquid pressure provided by the pump and acting on face **50** of valve disc **26** would no longer be present and valve disc **26** would be free to move in a downward direction so as to cover valve seat **24** and prevent the back-flow of liquid. Such downward movement of the valve disc occurs by force of gravity acting on the freely moveable valve disc and disc stem and also by a momentary back-flow of liquid which results in pressure being greater on back face **51** than on front face **50** of valve disc **26**. Such pressure difference closes and holds the valve disc against valve seat **24** until such pressure difference is reversed, such as by restarting of the pump. Such free movement of the disc stem **28** and valve disc **26** along disc stem longitudinal axis **40** can take place because of the lack of connection between disc stem **28** and actuator rod **42**.

A common problem with many check valves when a reversal of liquid flow direction occurs is "slamming" of the valve disc against the valve seat. Such slamming is greatly reduced in the valve of this invention by use of a compression spring **52** which biases the valve disc and its stem toward the closed position. Selection of spring characteristics is dependent on pressure of the liquid being pumped against valve disc face **50**. The spring is selected to be strong enough to assist in closing the valve when flow in the forward direction stops so that the valve is at least partially closed when the back-flowing liquid applies pressure to valve disc back face **51** and any slamming of the valve disc is reduced or eliminated because of the shortened distance the valve disc moves. The spring can not be so strong as to restrict flow in the forward direction in a significant amount. Spring **52** is shown in a partially compressed state in FIGS. 2, and 3 in a less compressed state in FIGS. 1 and 4.

FIGS. 5-7 show a second embodiment of a wye valve of the invention which includes a second component, in addition to the spring, to reduce or eliminate valve disc slamming. Wye valve **54** of FIGS. 5-7 with forward-flow indicated by arrows **56**, is similar to valve **10** of FIGS. 1-4, with the exception of an added hydraulic closing-speed regulator indicated generally at **58**. Such regulator consists of piston **60** attached to an upper end of disc stem **62**, cylinder sleeve **66**, solenoid valve **70**, check/needle valve **72**, hydraulic oil **74**, hydraulic oil reservoir **76**, and associated

piping. Piston **60** is free to move linearly along axis **68** in cylinder sleeve **66** with movement of valve disc **64**. The hydraulic closing-speed regulator operates so as to slow down valve closing during a reversal of liquid flow direction with substantially no effect on valve opening speed. The hydraulic circuit of the closing-speed regulator is shown in schematic form in FIG. 8. Shown are piston **60**, cylinder **66**, solenoid valve **70**, check/needle valve **72**, hydraulic oil reservoir **76** and hydraulic oil **74**. Solenoid valve **70** is open when energized and closes when not energized. Referring to FIGS. 5-8, when valve disc **64** is "opening" with movement in the direction indicated by arrow **78** (FIG. 8), flow of hydraulic oil is in the direction indicated by arrow **80**. When valve disc **64** is "closing" piston **60** moves in the direction indicated by arrow **79** and hydraulic oil flow is in the direction indicated by arrow **82**. During planned opening and closing, when loss of power is not a factor, and slamming of valve disc **64** is not a factor, solenoid valve **70** is energized and open so as to not require liquid flow through check/needle valve **72** (although a small flow can occur), and operational speed of the valve being operated by the electric motor is not affected.

During loss of power, when liquid flow is no longer in the direction of arrows **56** and back-flow is beginning in the direction of arrow **78** (FIG. 7), liquid pressure against back face **80** of valve disc **64** could, without closing-speed regulator **58**, slam valve disc **64** against valve seat **82**. To eliminate such

slamming solenoid valve **70** closes upon loss of power requiring flow of hydraulic oil through check/needle valve **72** in the direction indicated by arrow **82**. Valve **72** has two channels in parallel as best seen in FIG. 8. One channel includes needle valve **84** which adjustably controls hydraulic oil flow rate and the remaining channel includes check valve **86** which permits flow only in the downward direction (as when valve disc is opening). During valve disc closing, caused by liquid back-flow, hydraulic oil flow is in the direction indicated by arrow **82** and the hydraulic oil is forced to flow through the restricted channel of needle valve **84** at a controlled rate, thus slowing the movement of valve disc **64** against valve seat **82** and eliminating slamming. Such rate of closing is regulated by adjustment of the needle valve opening.

FIG. 9 shows another embodiment of the invention, an elbow valve **86** for use in a liquid conveying pipeline wherein a 90° pipeline configuration is available for placement of a valve. Normal liquid flow in a forward direction is indicated by arrows **88**. During normal operation, liquid flows from entry port **90** to outlet port **92** through valve seat **94**. As in the wye valve of FIGS. 1-7 valve closure is carried out by movement of actuator rod **96** downward by action of electric motor **98** to contact disc stem **100** to dispose valve disc **102** to cover valve seat **94** and achieve a closed position. Elbow valve **98** of FIG. 9 is depicted in the open position wherein valve disc **102** is spaced from valve seat **94**. Operation of elbow valve **98** is the same as wye valve **10** (FIGS. 1-

7). The valve disc position depicted in FIG. 8 is maintained by pressure of the liquid acting against face **104** of valve disc **102**. In the event of flow stoppage in the direction indicated by arrows **88**, back-flow of liquid is prevented by the action of gravity and spring **105** on freely moveable valve disc **102** and disc stem **100**, and momentary action of the back-flowing liquid on back-face **106** of valve disc **102** to move such disc downward to contact valve seat **94** and terminate the back-flow. Continued pressure on back face (**106**) maintains the valve in the back-flow preventing position.

Although elbow valve **88** with solely spring means **105** for reducing or eliminating valve disc slamming is shown, such elbow valve can be provided with hydraulic closing speed regulating means as shown and described for wye valve **10** (FIGS. 5-7) and operation of the two types of valves is the same.

A preferred method of operating a liquid pumping system utilizing a valve of the invention is schematically shown in FIG. 10. The system can be used in applications such as a municipal water supply system or a sewage treatment system. In FIG. 10 tank **108** is filled with liquid **110** by means of pump **112** acting on it. Pump input line **114** supplies the liquid to pump **112** and it is discharged through pump discharge line **116** toward liquid tank **108**. An electric motor actuated stop and self-closing check valve **10** of the invention having a wye configured body is installed to function as a pump control and stop check valve in liquid discharge line **116**. A common problem in water and sewage systems

utilizing such a pumping arrangement is liquid surge pressure transients and slamming of check valve components during pumping start-up and termination. Such problem is substantially eliminated with use of valve **10** in liquid discharge line **116**. In the preferred method of operation for pumping start-up, valve **10** is set to the closed position (FIG. 1) prior to start-up of pump **112**. That is actuator rod **42** is extended to locate and hold valve disc **26** against valve seat **24**. The pump is then started followed by opening of valve **10** toward the flow position (FIG. 2) at a selected rate with use of electric motor **41**. Such rate is controllable by motor control devices known in the art (not shown). Full flow position (FIG. 2) or reduced flow position (FIG. 3) is maintained during normal pumping operation. To achieve planned pumping shutdown without generating liquid surge pressure transients or valve component slamming, valve **10** is closed, or nearly closed, with use of electric motor **41** prior to shut-down of pump **112**. Following complete closure of the valve, or at a point nearing complete valve closure, the pump is switched off. Such sequential start-up and shut-down procedure can be conveniently controlled with use of switches and controls which coordinate the operation of the valve and the pump.

During normal pumping operation of the pumping system with flow of liquid in the direction of arrow **113**, and actuator rod **42** in the fully or partially retracted position (FIGS. 2-4) valve disc **26** is free to move in the direction toward valve seat

24 and close the valve to prevent back-flow of the liquid in the event of failure of pump 112 or loss of electrical power. No action is required by the electric motor or an operator for such back-flow preventing closing, as the valve is closed by action of the liquid flowing in a direction opposite to the direction of arrow 113. Spring 52 at least partially moves valve disc 26 toward the closed position during momentary liquid flow reversal from forward-flow to back-flow and valve disc slamming is eliminated or reduced. Such configuration and operating procedure for the pumping system enables conveying of liquid without undesirable liquid surging and slamming.

While specific materials and configurations have been set forth for purposes of describing embodiments of the invention, various modifications can be resorted to, in light of the above teachings, without departing from applicants' novel contributions; therefore in determining the scope of the present invention reference shall be made to the appended claims.